DOCKETED

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CA Title 24 Submission

Insert P2 S5 – Part II Section 5

HEATING-VENTILATION-AIR CONDITIONING-REFRIGERATION TECHNICIAN

O*NET-SOC CODE: 49-9021.01 RAPIDS CODE: 0637

Alternative Titles: Refrigeration Installer, Refrigeration Mechanic, Air Conditioning Mechanic, Mechanical Equipment Serviceman, Heating Technician, Heating Installer, Control System Installer, Building Automation Technician or Installer, Heating & Air Conditioning Technician/Mechanic

Amended
Work Process Schedule – Time-Based
HEATING-VENTILATION-AIR CONDITIONING-REFRIGERATION TECHNICIAN

O*NET-SOC CODE: 49-9021.01 RAPIDS CODE: 0637

Alternative Titles: Refrigeration Installer, Refrigeration Mechanic, Air Conditioning Mechanic, Mechanical Equipment Serviceman, Heating Technician, Heating Installer, Control System Installer, Building Automation Technician or Installer, Heating & Air Conditioning Technician/Mechanic

This craft specific schedule is attached to and is part of these Apprenticeship Standards for the above listed occupation and alternative titles.

1. **Term of Apprenticeship:**
   The term of the occupation shall be five (5) years with an On- the-Job-Learning (OJL) attainment of a minimum of 8,500 hours, which shall be supplemented by the required hours of instruction.

2. **Ratio of Apprentices to Journeyworkers:**
   The ratio of apprentice worker to the skilled journeyworker shall be determined by the local collective bargaining agreement.

3. **Apprentice Wage Schedule:**
   All apprentices shall be paid a progressively increasing schedule of wages based on a percentage of the current journeyworker's wage rate **or** as defined by the local collective bargaining agreement.

   Example: Term 8,500 hours

   1st 850 hours=45 % of a journeyworker's rate
   2nd 850 hours=50% of a journeyworker's rate
   3rd 850 hours=55% of a journeyworker's rate
   4th 850 hours=60% of a journeyworker's rate
   5th 850 hours=65% of a journeyworker's rate
   6th 850 hours=70% of a journeyworker's rate
   7th 850 hours=75% of a journeyworker's rate
   8th 850 hours=80% of a journeyworker's rate
   9th 850 hours=85% of a journeyworker's rate
   10th 850 hours=90% of a journeyworker's rate

4. **Schedule of Work Experience: (*See attached Work Process Schedule*)**
   Each apprentice shall receive instruction and work experience in all aspects of the occupation as listed in the work process schedule, which is attached, and made a part of, these standards. To permit the flexibility necessary to the sponsor's normal business operation, work process activities need not occur precisely in the order listed, nor do the scheduled hours in any activity need to be continuous. A record of work and training hours under each category of the work process shall be maintained for every apprentice. The JATC may modify or alter the work processes

to meet specific local needs prior to submitting these Standards to the appropriate registration agency for approval.

5. **Schedule of Related Instruction:** ***(See attached Related Instruction Outline)***

Each apprentice shall be required to receive at least ____ hours of related instruction (RI) in subjects related to the occupation for each year of training on the job. The apprentice may or may not be compensated for hours spent in RI outside of regular working hours. RI will be provided by utilizing various methods of instruction such as traditional classroom (lecture, discussion), electronic media (including, but not limited to: online training, distance learning) and practical (hands on) learning. Related instruction will include a mechanism to verify satisfactory understanding (assessment) of the subject matter. Curriculum will be both skill and knowledge based upon accepted industry standards and practices. Each apprentice shall maintain an achievement grade in related instruction of at least 70 percent, in order to advance to each level of the apprenticeship.

Amended
Work Process Schedule – Hybrid
HEATING-VENTILATION-AIR CONDITIONING-REFRIGERATION TECHNICIAN

O*NET-SOC CODE: 49-9021.01 RAPIDS CODE: 0637HY

Alternative Titles: Refrigeration Installer, Refrigeration Mechanic, Air Conditioning Mechanic, Mechanical Equipment Serviceman, Heating Technician, Heating Installer, Control System Installer, Building Automation Technician or Installer, Heating & Air Conditioning Technician/Mechanic

This craft specific schedule is attached to and is part of these Apprenticeship Standards for the above listed occupation and alternative titles.

1. **Term of Apprenticeship:**
   The term of the occupation shall be five (5) years with an On- the-Job-Learning (OJL) attainment of 8,500 to 10,000 hours, which shall be supplemented by the required hours of instruction.

2. **Ratio of Apprentices to Journeyworkers:**
   The ratio of apprentice worker to the skilled journeyworker shall be determined by the local collective bargaining agreement.

3. **Apprentice Wage Schedule:**
   All apprentices shall be paid a progressively increasing schedule of wages based on a percentage of the current journeyworker's wage rate **or** as defined by the local collective bargaining agreement.

   Example: Term 8,500 – 10,000 hours

   1st 850 – 1000 hours=45 % of a journeyworker's rate
   2nd 850 – 1000 hours=50% of a journeyworker's rate
   3rd 850 – 1000 hours=55% of a journeyworker's rate
   4th 850 – 1000 hours=60% of a journeyworker's rate
   5th 850 – 1000 hours=65% of a journeyworker's rate
   6th 850 – 1000 hours=70% of a journeyworker's rate
   7th 850 – 1000 hours=75% of a journeyworker's rate
   8th 850 – 1000 hours=80% of a journeyworker's rate
   9th 850 – 1000 hours=85% of a journeyworker's rate
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To ensure that all United Association (UA) apprentices and journeyworkers receive the appropriate skills and knowledge from any of the 330 UA authorized training centers (covering 284 registered apprenticeship programs and over 40,000 registered apprentices), the International Pipe Trades Joint Training Committee (IPTJTC) has committed tremendous resources to the development of curriculum, standards and certifications (including 3rd party groups[1]). The IPTJTC works in partnership with government, education, and industry groups (private and non-profit) in the development and validation of this material to assist in preparing these individuals for a successful career in the piping industry.

Optional Requirements for Interim Credentials for HVACR

Level 1 1,700 – 2000 Hours OJL and 1st Year RI

- Completion of Brazing Certification UA–51 -The completed braze test assembly shall be visually examined for cleanliness and the presence of brazing filler metal all around the joint at the interface between the socket and the pipe. Outside surfaces shall be free of excessive braze metal and oxidation. Sectioning Tests shall be in accordance with ASME Code Section IX.

- OSHA 10-Hour Course - Smart Mark is an OSHA approved safety and health training program. It is a standardized and intensive program that was developed in 1998 by the Construction Industry Partnership (CIP) that prepares construction industry workers to identify hazards and prevent on-the-job accidents.

Level 2 3,400 – 4,000 Hours OJL and 2nd Year RI

- CFC Universal Certification - Overview of the issues on the U. S. Environmental Protection Agency's (EPA) certification under Section 608 include:
  Core Information
  Type 1 Certification (Small Appliances)
  Type 2 Certification (High-Pressure)
  Type 3 Certification (Low-Pressure)

- R410A Certification - The HVACR industry has been using Hydrochlorofluorocarbons (HCFCs) since the 1940s. Due to environmental and competitive pressure, HCFCs including R-22 are being phased-out. In response, many of the manufacturers began selling equipment that uses HFC-410A. R-410A presently marketed under the brand names Honeywell AZ-20, Carrier Puron, or DuPont Suva. Air conditioning equipment manufactured for R-410A will require contractors and technicians to shift to different tools, equipment and safety standards when installing or changing out older split A/C systems and repairing systems in the field. R-410 has a much higher vapor pressure than R-22. These higher pressures

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create some safety concerns. To address the issues of safe handling, training and certification with the uses of R-410A, the industry worked together to unify behind a Universal R-410 Safety Training & Certification program. The AC&R Safety Coalition members include RSES, ESCO Institute, Ferris State University, Indoor Air Quality Association, Industrial Technology Excellence, Green Mechanical Council, HVAC Excellence, COSA and the United Association. Together working with numerous manufacturers, wholesalers and industry associations a third party has developed a universal R-410A curriculum and certification.

- Green Systems Awareness Certification – The certification consists of four parts. In order to receive this certification a member must achieve an 80% on each four parts, which include Core; HVAC; Plumbing and Electrical. No certification is given if they fail one or more sections.

Level 3 5,100 – 6,000 Hours OJL and 3rd Year RI

The apprentice may complete either the UA Star Refrigeration Commercial Service Technician or the UA Star Residential and Light Commercial Certification for the Level 3 certification.

- UA STAR Commercial Refrigeration Service Technician – The UA STAR Certification exam was developed by the UA and Ferris State University – one of the most highly acclaimed providers of education programs in the industry. This certification relates to the nine categories and 32 tasks identified during the DACUM process administered by Ferris State University. The DACUM is an in-depth job and task analysis that serves as the base for the UA STAR exam. The UA STAR exam is a comprehensive exam. It is designed to test the knowledge of the experienced technician. The information contained in the reference materials alone will not produce a qualified technician—experience is also required.

- UA Star Residential and Light Commercial Certification – The UA STAR Certification exam was developed by the UA and Ferris State University—one of the most highly acclaimed providers of education programs in the industry. The exam is administered based on the skills developed around the work

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processes. This certification relates to the 11 categories and 46 tasks identified during the DACUM process administered by Ferris State University. The DACUM is an in-depth job and task analysis that serves as the base for the UA STAR exam. The UA STAR exam is a comprehensive exam. It is designed to test the knowledge of the experienced technician. The information contained in the reference materials alone will not produce a qualified technician—experience is also required.

The apprentice must complete each level of the above requirements and certifications to be eligible to receive an Interim Credential Certification from the United States Department of Labor's Office of Apprenticeship. The Interim Credential will read the following for each level:

Level 1 – Completion of Brazing Certification UA-51

OSHA 10 Course

Level 2 – CFC Universal

R410A and

Green Systems Awareness Certification

Level 3 – UA Star Residential and Light Commercial Certification or

UA Star Refrigeration Commercial Service Technician Certification

The Certificate of Completion of Apprenticeship will be issued when the last year of apprenticeship is completed with all remaining requirements.

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UA-51 BRAZE TEST SPECIFICATION

Manual Torch Brazing Process

Maximum Time Permitted for Test is Two Hours

COUPON MATERIALS

- Tube Material: SB-75 Seamless Tube (0.060" wall)
- Fitting Material: B16.22 Stop Coupling (0.055" wall)
- Fitting/Tube Size: 1 ½" Type L (1.625" OD Tube)
- Number of Coupons: Two Socket Couplings, Four Joints Total

JOINT CONFIGURATION

- Socket Joints Required
- Socket Clearance: 0.002" to 0.010"
- Overlap of Socket and Pipe: 1.09"

FLOW POSITION

- Two Joint in Each the Horizontal and Vertical Up-Flow Positions
- Face Fed Filler Metal

BRAZING FILLER MATERIALS

- Filler Metal: BCuP-2 Through BCuP-7
- Product Form: Round, Square, or Rectangular Rod

BRAZING FLUX

- None Permitted

FUEL GAS

Oxyacetylene, Natural, Propane, or MAPP® Gas

INTERNAL PURGING

- Oil Free Dry Nitrogen ≥ 5 CFH (The purge gas shall flow until the brazement is cool to the touch so that no oxidation forms on the I.D. of the tube and fitting.)

GENERAL BRAZING TECHNIQUES

- Prebraze Cleaning: Surface particles and dirt shall be removed using a clean lint-free cloth. Surface oxidation shall be removed with the use of a nylon abrasive cloth.

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- Postbraze Cleaning: Use a wet cloth or stainless steel wire brush to remove loose surface oxidation.
- Nature of Flame: Neutral
- Brazing Tip Sizes: (Optional) 54 Through 30: Use of Turbo Torch or Rosebud Permitted.

INSPECTION AND TESTING

- The completed braze test assembly shall be visually examined for cleanliness and the presence of brazing filler metal all around the joint at the interface between the socket and the pipe. Outside surfaces shall be free of excessive braze metal and oxidation.
- Assembly shall be examined by Sectioning Tests in accordance with ASME Code Section IX.

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DESIGNATED TRAINING TOPICS

10-HOUR CONSTRUCTION INDUSTRY OUTREACH TRAINING PROGRAM
10-HOUR MANDATORY COURSE TOPICS

The 10-hour Construction Industry Outreach Training Program is intended to provide an entry-level construction worker's general awareness on recognizing and preventing hazards on a construction site. The training covers a variety of construction safety and health hazards which a worker may encounter at a construction site. OSHA recommends this training as an orientation to occupational safety and health. Workers must receive additional training on hazards specific to their job. Training should emphasize hazard identification, avoidance, control and prevention, not OSHA standards. Instructional time must be a minimum of 10 hours.

Breakdown of topics is as follows:

- **Mandatory – 4 Hours**: Four topics to be taught, ranging from one-half to two hours each (Introduction to OSHA; OSHA Focus Four Hazards; Personal Protective and Lifesaving Equipment; Health Hazards in Construction).
- **Elective – 2 Hours**: Choose at least two of these topics for a minimum of one-half hour each. Must cover at least two hours.
- **Optional – 4 Hours**: Learn any other construction industry hazards or policies and/or expand on the mandatory or elective topics, minimum of one-half hour each.

10-HOUR CONSTRUCTION INDUSTRY REQUIREMENT COURSE TOPICS

Introduction to OSHA – One Hour

- OSH Act, General Duty Clause, Employer and Employee Rights and Responsibilities, Whistleblower Rights, Recordkeeping basics
- Inspections, Citations, and Penalties
- General Safety and Health Provisions, Competent Person, Subpart C
- Value of Safety and Health
- OSHA Website, OSHA 800 number and available resources

OSHA Focus Four Hazards – Two Hours (must cover all four areas – minimum 15 minutes on each)

- Fall Protection, Subpart M (e.g., floors, platform, roofs)
- Electrical, Subpart K (e.g., overhead power lines, power tools and cords, temporary wiring, grounding)
- Struck by (e.g., falling objects, trucks, cranes)
- Caught in/between (e.g., trench hazards, equipment)

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Personal Protection and Lifesaving Equipment – 30 Minutes, Subpart E

Health Hazards in Construction – 30 Minutes (e.g., noise, hazards communication and crystalline silica)

ELECTIVES

Choose at least two of the following topics – must add up to at least two hours: Minimum one-half hour each

- Materials Handling, Storage, Use and Disposal, Subpart H
- Tools – Hand and Power, Subpart I
- Scaffolds, Subpart L
- Cranes, Derricks, Hoists, Elevators, and Conveyors, Subpart N
- Excavations, Subpart P
- Stairways and Ladders, Subpart X

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Universal Certification for EPA under Section 608

CORE

Ozone Depletion

- Destruction of ozone by chlorine
- Presence of chlorine in CFC and HCFC refrigerants
- Identification of CFC, HCFC, and HFC refrigerants (not chemical formulas, but idea that R-12 is a CFC, R-22 is an HCFC, R-134 is an HFC, etc.)
- Idea that CFCs have higher ozone-depletion potential (ODP) than HCFCs, which in turn have higher ODP than HFCs
- Health and environmental effects of ozone depletion
- Evidence of ozone depletion and role of CFCs and HCFCs

Clean Air Act and Montreal Protocol

- CFC phase-out date
- Venting prohibition at servicing
- Venting prohibition at disposal
- Venting prohibition on substitute refrigerants in November 1995
- Maximum penalty under CAA
- Montreal Protocol (international agreement to phase out production of ozone-depleting substances)

Section 608 Regulations

- Definition/identification of high- and low-pressure refrigerants
- Definition of system-dependent vs. self-contained recovery/recycling equipment
- Identification of equipment covered by the rule (all air-conditioning and refrigeration equipment containing CFCs or HCFCs, except motor vehicle air conditioners)
- Need for third-party certification of recycling and recovery equipment manufactured after November 15, 1993
- Standard for reclaimed refrigerant (ARI 700)

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Substitute Refrigerants and Oils

- Absence of "drop-in" replacements
- Incompatibility of substitute refrigerants with many lubricants used with CFC and HCFC refrigerants and incompatibility of CFC and HCFC refrigerants with many new lubricants (includes identification of lubricants for given refrigerants, such as esters with 134; alkyl benzenes for HCFCs)
- Fractionation problem—tendency of different components of blends to leak at different rates

Refrigeration

- Refrigerant states (vapor vs. liquid) and pressures at different points of refrigeration cycle; how/when cooling occurs
- Refrigeration gauges (color codes, ranges of different types, proper use)

Three R's

- Definitions:
    1. Recover
    2. Recycle
    3. Reclaim

Recovery Techniques

- Need to avoid mixing refrigerants
- Factors affecting speed of recovery (ambient temperature, size of recycling or recovery equipment, hose length and diameter, etc.)

Dehydration Evacuation

- Need to evacuate system to eliminate air and moisture at the end of service

Safety

- Risks of exposure to refrigerant (e.g., oxygen deprivation, cardiac effects, frostbite, long-term hazards)

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- Personal protective equipment (gloves, goggles, self-contained breathing apparatus—SCBA—in extreme cases, etc.)
- Reusable (or "recovery") cylinders vs. disposable cylinders (ensure former DOT approved, know former's yellow and gray color code, never refill latter)
- Risks of filling cylinders more than 80 percent full
- Use of nitrogen rather than oxygen or compressed air for leak detection
- Use of pressure regulator and relief valve with nitrogen

Shipping

- Labels required for refrigerant cylinders (refrigerant identification, DOT classification tag)

TYPE 1 (Small Appliances)

Recovery Requirements

- Definition of "small appliance"
- Evacuation requirements for small appliances with and without working compressors using recovery equipment manufactured before November 15, 1993
- Evacuation requirements for small appliances with and without working compressors using recovery equipment manufactured after November 15, 1993

Recovery Techniques

- Use of pressure and temperature to identify refrigerants and detect noncondensables
- Methods to recover refrigerant from small appliances with inoperative compressors using a system-dependent or "passive" recovery device (e.g., heat and sharply strike the compressor, use a vacuum pump with non-pressurized recovery container)
- Need to install both high and low side access valves when recovering refrigerant from small appliances with inoperative compressors

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- Need to operate operative compressors when recovering refrigerant with a system-dependent or "passive" recovery device
- Should remove solderless access fittings at conclusion of service
- 134a as likely substitute for 12

Safety

- Decomposition products of refrigerants at high temperatures (HCl, HFl etc.)

TYPE 2 (High-Pressure)

Leak Detection

- Signs of leakage in high-pressure systems (excessive superheat, traces of oil for hermetics)
- Need to leak test before charging or recharging equipment
- Order of preference for leak test gases (nitrogen alone best, but nitrogen with trace quantity of 22 better than pure refrigerant)

Leak repair requirements

- Allowable annual leak rate for commercial and industrial process refrigeration
- Allowable annual leak rate for other appliances containing more than 50 lbs of refrigerant

Recovery Techniques

- Recovering liquid at beginning of recovery process speeds up process
- Other methods for speeding recovery (chilling recovery vessel, heating appliance or vessel from which refrigerant is being recovered)
- Methods for reducing cross-contamination and emissions when recovery or recycling machine is used with a new refrigerant
- Need to wait a few minutes after reaching required recovery vacuum to see if system pressure rises (indicating that there is still liquid refrigerant in the system or in the oil)

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Recovery Requirements

- Evacuation requirements for high-pressure appliances in each of the following situations:
    1. Disposal
    2. Major vs. non-major repairs
    3. Leaky vs. non-leaky appliances
    4. Appliance (or component) containing less vs. more than 200 lbs
    5. Recovery/recycling equipment built before vs. after November 15, 1993
- Definition of "major" repairs
- Prohibition on using system-dependent recovery equipment on systems containing more than 15 pounds of refrigerant

Refrigeration

- How to identify refrigerant in appliances
- Pressure-temperature relationships of common high-pressure refrigerants (may use standard temperature-pressure chart—be aware of need to add 14.7 to translate psig to psia)
- Components of high-pressure appliances (receiver, evaporator, accumulator, etc.) and state of refrigerant (vapor vs. liquid) in them

Safety

- Should not energize hermetic compressors under vacuum.
- Equipment room requirements under ASHRAE Standard 15 (oxygen deprivation sensor with all refrigerants)

TYPE 3 (Low-Pressure)

Leak Detection

- Order of preference of leak test pressurization methods for low-pressure systems (first: hot water method or built-in system heating/pressurization device such Prevac; second: nitrogen)

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- Signs of leakage into a low-pressure system (e.g., excessive purging)
- Maximum leak test pressure for low-pressure centrifugal chillers

Leak Repair Requirements

- Allowable annual leak rate for commercial and industrial process refrigeration
- Allowable annual leak rate for other appliances containing more than 50 lbs of refrigerant

Recovery Techniques

- Recovering liquid at beginning of recovery process speeds up process
- Need to recover vapor in addition to liquid
- Need to heat oil to 130°F before removing it to minimize refrigerant release
- Need to circulate or remove water from chiller during refrigerant evacuation to prevent freezing
- High-pressure cut-out level of recovery devices used with low-pressure appliances

Recharging Techniques

- Need to introduce vapor before liquid to prevent freezing of water in the tubes
- Need to charge centrifugals through evaporator charging valve

Recovery Requirements

- Evacuation requirements for low-pressure appliances in each of the following situations:
    1. Disposal
    2. Major vs. non-major repairs
    3. Leaky vs. non-leaky appliances
    4. Appliance (or component) containing less vs. more than 200 lbs
    5. Recovery/recycling equipment built before vs. after November 15, 1993

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- Definitions of "major" and "non-major" repairs
- Allowable methods for pressurizing a low-pressure system for a non-major repair (controlled hot water and system heating/pressurization device such as Prevac)
- Need to wait a few minutes after reaching required recovery vacuum to see if system pressure rises (indicating that there is still liquid refrigerant in the system or in the oil)

Refrigeration

- Purpose of purge unit in low-pressure systems
- Pressure-temperature relationships of low-pressure refrigerants

Safety

- Equipment room requirements under ASHRAE Standard 15 (oxygen deprivation sensor with all refrigerants)
- Under ASHRAE Standard 15, need to have equipment room refrigerant sensor for 123

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R-410A Course Content

R-410A and the R-22 Phase-Out

- HCFC Phase-Out Schedule
- Regulation and Change
- The Future
- Safety and R-410A

Refrigeration & Air Conditioning Systems Fundamentals

- Vapor Compression System
- Condensing Pressure
- Evaporating Pressure
- Refrigerant States & Conditions
- Saturation
- Vapor Pressure
- Superheat
- Subcooling

R-410A Considerations

- Compressor
- Compression Ratios
- Condenser
- Receiver
- Filter/Driers
- Liquid Line
- Metering Device
- Evaporator
- Suction Line

Refrigerant Chemistry & Applications

- Chlorofluorocarbons (CFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Hydrofluorocarbons (HFCs)
- Blends
- Blend Fractionation
- Blend Temperature Glide
- Superheat & Subcooling
- Calculation for Near-Azeotropic Blends
- Subcooling & Superheat with
- Temperature Glide
- Evaporator Superheat Calculation
- Condenser Subcooling Calculations
- Blend Lubricants

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HCFC-22 Replacement Candidates

- R-410A
- Typical Operating Pressures
- Temperature Glide & Fractionation
- Pressure/Temperature Chart
- R-407C
- Temperature Glide & Fractionation

Basic Service Tools

- Gauge Manifold
- R-410A Considerations
- Micron Gauge
- Vacuum Pumps
- R-410A Considerations
- Leak Detectors
- R-410A Considerations

Refrigerant Recovery Systems

- Passive Recovery (System Dependent)
- Active Recovery (Self-Contained)
- R-410A Considerations

Refrigerant Charging

- Undercharge
- Overcharge

R-410A System Charging

- Charging for Proper Subcooling
- Charging for Proper Superheat
- Precautions

R-407C System Charging

R-407C Refrigerant Leaks & Leak Detectors

Refrigeration Oils & Applications

- Oil Groups
- Synthetic Oils
- Alkybenzene
- Glycols
- Esters
- Waste Oils
- Lubricants, R-410A, R-407C & R-134A
- Advantages of POE vs. Mineral Oils
- Concerns with POE Lubricants

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Safety

- Personal Safety Protection
- Electrical Safety
- Safe Refrigerant Handling
- Storage Cylinders
- Shipping
- ASHRAE Standard 34
- Equipment Room/Jobsite Safety
- Monitors/Alarms

Ventilation

- Purge Venting
- Breathing Apparatus

Safety Overview

- R-410A Considerations
- Material Safety Data Sheet
- Toxicity
- Flammability
- Combustibility
- Ingestion
- Skin/Eye Contact
- Inhalation
- Refrigerant Decomposition

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UA Green Systems Awareness Certification

Section I – Core

Energy Analysis and Awareness
Renewable Energy & Sustainable Energy
Energy Management
Building Information Modeling (BIM)
Commercial Building Energy Consumption Survey (CBECS)
Energy Conservation Measures (ECM)
Energy Information Administration (EIA)
Energy Audit
Energy Consumption and Demand Analysis
Heat load calculation
Life Cycle Cost Analysis 1
Worksheet #1

Section II – HVAC/R

Heating -Ventilation-Air Conditioning-Refrigeration
Energy Efficiency Ratings
Energy Efficiency Ratio
Seasonal Energy Efficiency Ratio
Annual Fuel Utilization Efficiency
Heating Season Performance Factor
Coefficient of Performance (COP)
Comfort Conditioning
Ventilation and Indoor Air Quality
Comfort Cooling Methods and Green Alternatives
Mechanical Air Conditioning
Evaporative Cooling
Passive Cooling Systems
Solar Cooling
Thermal Storage
Commercial Refrigeration
U.S. EPA GreenChill (Advanced Refrigeration Partnership)
Refrigerant Containment Practices
Energy Conservation Measures
New and Replacement Equipment
Comfort Heating Methods and Green Alternatives
Combustion Analysis
Forced Air
Condensing Furnaces

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Modulating Furnaces
Condensing Boilers
Instantaneous Boiler
Solar Water Comfort Heating
Solar Air Heating
Waste Heat Recovery
Radiant Panel Systems
Thermal Mass
Optimized Steam Systems
Steam Traps
Comfort Heating and Cooling Combination Systems and Green Alternatives
Geothermal Systems
Air-to-Air Heat Pumps
Packaged Terminal Air Conditioners (PTAC)
Mini-Split Systems
Worksheet #2

Section III – Electrical

Electrical Production and Consumption
Electrical Power
Nuclear Energy
Fuel Cells
Photovoltaic
Wind Turbines
Motor Efficiency
Lighting
Fluorescent
LED
Tidal and Ocean Energy
Ghost Loads
Residential Major Appliances
Worksheet #3

Section IV – Plumbing

Hydrologic Cycle
Potable Water Conservation
Flow Restriction
Faucets / Showerheads / Pre-Rinse Spray Valves
High Efficiency Plumbing Fixtures
Water Closets
Ultra Low Flush

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Dual Flush
Ultra Low Flush Urinal
Waterless Fixtures
Removable Cartridge/Insert Waterless Urinal
Cartridge Free Waterless Urinals
Composting Toilet
High Efficiency Plumbing Appliances
Clothes Washers
Dishwashers
Ice Machines
Garbage Disposals
Hot Water Distribution Systems
Hot Water Circulating Systems
On Demand Water Circulating System
Gravity Water Circulating Systems
Dedicated Line Water Circulating Systems
Water Distribution Piping Installation
Protection of the Water Distribution System
Water Heating Equipment
Storage Water Heaters
Demand (Tankless) Water Heaters
Heat Pump Water Heaters
Indirect Water Heaters
Solar Water Heaters
First Hour Rating
Wastewater Reuse Systems
Landscape Irrigation Systems
Drain Water Heat Recovery System
Gray Water and Reclaimed Water Reuse Systems
Reclaimed Water Systems
Gray Water Systems
Rain Water Harvesting
Fire Protection Systems and the Environment
Industrial Fire Protection Systems
Residential Fire Protection Systems
Green Plumbing System Relevance to LEED
Worksheet #4
LEED Worksheet
Summary

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UA STAR Residential Light Commercial Certification

Category A: Applied Science & Math

TASK 1. Matter, Energy and Science of Heat Basics

Matter (solids, liquids, gases)
Energy
- First and Second Law of Thermodynamics
- Work
- Power

Heat
- Heat and Power Relationship
- Temperature and Temperature Scales
- Heat Transfer
- Sensible Heat
- Latent Heat

Pressure
- Atmospheric Pressure
- Vacuum Pressure
- Vacuum Pressure Calculations and Conversions

Reference
United Association HVACR Training Manual, Unit 1 and 2

TASK 2. The Refrigeration Process

The Refrigeration Process
- Pressure/Temperature Relationship
- Evaporators
- Compressors
- Condensers
- Metering Devices

Refrigerants in the Residential Systems
- R-22
- R410A

The Vapor-Compression Refrigeration Cycle
- Putting It Together
- Outside Air Conditioners
- From the Compressor
- In the Condenser

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- Through the Metering Devices
- Indoor Air Conditions
- Absorbing Heat in the Evaporator
- In the Compressor

Reference
United Association HVACR Training Manual, Unit 3
P/T Chart

TASK 3. Applied HVAC Math

Basic Algebra
CFM
Measuring (linear, cubic, square, volume)
GPM (flow rates)
Pulley Formula
Micron
Conversions

Reference
United Association HVACR Training Manual
UA Star Equation Sheet
Related Mathematics

Category B: Safety

TASK 4. Personal Safety

Clothing
Jewelry
Safety Glasses
Work Boots
Ear Plugs
Gloves
Lifting Objects and Back Support Belts

Reference
United Association HVACR Training Manual

TASK 5. Electrical Safety

Electric Shock

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Ground Wires
Extension Cords and Ground Prongs
Ground-Fault Circuit Interrupters

Reference
United Association HVACR Training Manual, Unit 4

TASK 6. Fire Safety

Class A, B, C, and D Fire Extinguishers
Multiple Purpose Fire Extinguishers
Fire Extinguisher Use
Fire Extinguisher Maintenance

Reference
www.hanford.gov/fire/extinrs.htm#fetypes

TASK 7. Tools, Equipment, and Material Safety

Wrenches
Screwdrivers
Ladders
Soldering and Brazing Equipment
Pressurized Gas Tanks and Cylinders
Chemical and Material Safety

Reference
United Association HVACR Training Manual, Unit 4

TASK 8. First Aid

Frostbite
Bleeding
Asphyxiation
Chemical Burns
Electric Shock

Reference
United Association HVACR Training Manual, Unit 4
www.chp.edu/besafe/adult/02frostbite.php?base=hs

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TASK 9. Agencies

Occupational Safety and Health Administration (OSHA)
National Fire Protection Agency (NFPA)
American National Standards Institute (ANSI)

Reference
http://www.osha.gov/
http://www.ansi.org/

Category C: Installation

TASK 10. Unit Location and the Air Distribution System

Condensing Unit Location
- Sound Transmission
- Wind Factors
- Location of Electrical Power
- Airflow Restrictions
- Proximity to the Indoor Unit
- Ground Slope

Indoor Unit Location
- Types of Air-Distribution Systems
- Location of Electrical Power Supply
- Length of the Refrigerant Lines
- Serviceability
- Indoor Unit Configuration
- Ease of Condensate Removal
- Noise Level
- Return Air
- Location of the Space to Be Conditioned

Air-Distribution System
- Duct System Configuration
- Duct System Materials
- Combination Duct Systems
- Insulating and Wrapping Duct Systems
- Sealing Duct Systems
- Install Galvanized Metal Duct Systems
- Install Flexible Duct Systems
- Install Fiberglass Duct Systems
- Install Round Sheet Metal Duct Systems

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Reference

United Association HVACR Training Manual, Unit 37

TASK 11. System Connections

Piping Materials
- Fittings
- Copper Pipe
- Plastic Pipe

Installation, Supporting and Insulating Refrigerant Lines
- Length of the Piping Run
- Choices of Pipe Fittings
- Solder and Solder Joints
- Refrigerant Traps

Installing, Supporting, and Insulating Condensate Drain Lines
- Drain Line Size
- Drain Line Materials
- Pitching the Line
- Traps
- Drain Line Terminations
- Auxiliary Drain Pans
- Safety Float Switches

System Wiring
- Line Voltage Power Circuit Wiring
- Low Voltage Control Wiring

Leak-Checking the System
- Pressurizing the System
- Marking the Gage

Use Tubing Cutters
Swag Soft-Drawn Copper Tubing
Flare Soft-Drawn Copper Tubing
Solder
Braze
Join Plastic Pipe

Reference

United Association HVACR Training Manual, Unit 7

TASK 12. System Evacuation, Efficiency, Startup, and Charging

System Evacuation

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- The Vacuum Pump
- Vacuum Pump Oil
- Acceptable Levels of Vacuum

System Holding Charge
Pre-Startup Checklist

- Condensing Unity
- Air Handler
- Duct System
- General

System Startup

- Airflow Through the Condensing Unit
- Airflow Through the Air Handler
- System Pressures
- Temperature Differential Across the Evaporator Coil
- Evaporator Superheat
- Condenser Subcooling

System Charging

- System Overcharge
- Removing Excess Refrigerant from the System
- System Undercharge
- Charging the System Using Manufacturers' Charging Tables and Charts

Drain and Replace Vacuum Pump Oil
Calibrate the Gage Manifold
Evacuate the Air Conditioning System
Measure the Superheat in an Air Conditioning System
Measure the Temperature Differential across the Evaporator Coil
Remove Refrigerant from an Operating Air Conditioning System
Add Refrigerant to an Air Conditioning System

Reference
United Association HVACR Training Manual, Unit 8, 10, 21, 38

Category D: Comfort Cooling

TASK 13. Indoor Air Quality

Remove the Source of Contaminant
Provide Adequate Air Cleaning
Provide Adequate Ventilation
Mold
UV Light

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Reference

United Association HVACR Training Manual, Unit 34

TASK 14. Air filtration

Foam Filters
Fiberglass Filters
Extended Surface Filters
Steel Filters
High Efficiency Particulate Arrester Filters
Electrostatic Air Filters
Electronic Air Filters

Reference

United Association HVACR Training Manual, Unit 34

TASK 15. Humidity and Humidification

Humidifiers

- Freestanding, Self-Contained Humidifiers
- Duct-Mounted Humidifiers

Reference

United Association HVACR Training Manual, Unit 34

TASK 16: Installing and Troubleshooting Air Quality Devices

Fresh Air and Ventilators
Troubleshooting and Maintaining Air Quality Devices

Reference

United Association HVACR Training Manual, Unit 34

Category E: Comfort Cooling Troubleshooting

TASK 17. Evaporator and Condenser Fan Motor Problems

Improper Airflow
Improper Motor Lubrication
Improper Pulley Alignment
Improper Belt Tension

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Reference

United Association HVACR Training Manual
Commercial Refrigeration for Air Conditioning Technicians
Electricity for Heating Refrigeration and Air Conditioning

TASK 18. Refrigerant Charge Related Problems

System Pressure Readings
Complete Loss of Refrigerants Charge
System Contamination

Reference

United Association HVACR Training Manual

TASK 19. Evaluating the Metering Device

Evaluating the Capillary Tube
Evaluating the Automatic Expansion Valve
Evaluating the Thermostatic Expansion Valve

Reference

United Association HVACR Training Manual, Unit 24

TASK 20. Troubleshooting Steps

Service call 1: System Overcharge
Service call 2: System Undercharge
Service call 3: Dirty Air Filter

Reference

United Association HVACR Training Manual

Category F: Refrigerant Management

TASK 21. Refrigerant and Oil Types

Refrigerant Types

- Hydrocarbon Refrigerants
- Hydrochlorofluorocarbon Refrigerants
- Chlorofluorocarbon Refrigerants
- Hydrofluorocarbon Refrigerants

Blended Refrigerants

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Ozone, Ozone Depletion, and Global Warming
Refrigerant Oils
- Alkylbenzene Oils
- Glycols
- Esters

Safety Classifications and Nomenclature

Reference
United Association HVACR Training Manual, Unit 9

TASK 22. Refrigerant Handling and Transporting Regulations

Government Regulations
EPA Type 608 Certification (410A)
- Type I
- Type II
- Type III
- Universal Certification

410A
Refrigerant Recovery (Passive and Active Recovery)
Refrigerant Recycling
Refrigerant Reclaiming
Procedures
- Recovering Refrigerant from a System with an Operative Compressor
- Recovering Refrigerant from a System with a Self-Contained Recovery Unit

Reference
United Association HVACR Training Manual, Unit 9

Category G: Basic Electricity

TASK 23. Electrical Theory

Direct Current
Alternating Current
Ohms Law
Atomic Theory
Electron Orbits
Law of Charges
Conductors
Insulators
Magnetism

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Electrical Quantities

Reference
HVAC Light Commercial STC Version 1-11-06
Electricity for Heating Refrigeration and Air Conditioning

TASK 24. Measuring Instruments

Voltmeters
Ammeters
Ohmmeters
Analog meters
Digital meters
Multimeters
Megometer
Micro-Amp Meter

Reference
HVAC Light Commercial STC Version 1-11-06

TASK 25. Electrical Circuits (Series and Parallel)

Wiring Diagrams
Wire Size
Circuit Protection (Fuses, Circuit Breakers, GFCI)

Reference
HVAC Light Commercial STC Version 1-11-06
Electricity for Heating, Refrigeration and Air Conditioning

TASK 26. Electric Service

120/240 V. Single-Phase Service
Three-Phase Service

Reference
HVAC Light Commercial STC Version 1-11-06
Electricity for Heating, Refrigeration and Air Conditioning

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Category H: Controls

TASK 27. Electric Motors and Starting Components

Motor Uses
Motor Power and Starting Torque
Motor Types
Single-Phase Motors
- Shaded-Pole Motors
- Split-Phase Motors
- Capacitor-Start-Induction Motors
- Permanent-Split-Capacitor Motors
- Capacitor-Start-Capacitor-Run Motors

Three-Phase Motors
- Motor Starters
- Stator Windings: Wye Configuration
- Stator Windings: Delta Configuration
- Three-Phase Motor Starting

Variable Speed Motors
Procedures
- Identifying the Common, Start, and Run Terminals on a Split-Phase Motor
- Checking the Coil and Contacts on a DMR
- Checking the Coil and Contacts on a PMR
- Check Capacitors

Reference
HVAC Light Commercial STC Version 1-11-06
Electricity for Heating Refrigeration and Air Conditioning

TASK 28. Automatic Controls and Devices

Overloads
Overload on Three-Phase Motors
Limit Switches
Fan Switches
Fan-Limit Switches
Thermostats
- Line-Voltage Thermostats
- Low-Voltage Thermostats

Magnetically Operated Devices
- Solenoids
- Control Transformers

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- Variable-Speed Motor Controls

Electromagnetic Devices

- Relays
- Contactors
- Motor Starters
- Defrost Timers
- Flow Switches
- Float Switches

Pressure Switches and Controls

- High-Pressure Controls
- Low-Pressure Controls
- Dual-Pressure Controls

Electronic Controls

- Residential Air Conditioning Appliances
- Electronic Thermostats
- Solid-State Relays
- Solid-State Starting Relays
- Solid-State Timers

Reference

United Association HVACR Training Manual
Electricity for Heating, Refrigeration and Air Conditioning

TASK 29. Electrical Troubleshooting

Control-Circuit Problems

- Holding Coils
- Thermostats
- Transformers
- Control Fuses
- Pressure Controls and Safety Devices
- Lock-Out Circuits

Power-Circuit Problems

- Contactors and Relay Contacts
- Circuit Breakers and Fuses
- Fan Motors and Compressor Motors
- Capacitors
- Utility Supply Problems (under and over Voltage Problems)

Service Call 1: Blown Line Voltage Fuse
Service Call 2: Defective Transformer
Service Call 3: Defective Contactor

[1]**NITC – National Inspection Testing Corporation; EPA – Environmental Protection Agency; OSHA –Occupational Safety and Health Administration; EPRI – Electric Power Research Institute; ESCO Institute; ASSE – American Society of Safety Engineers; NCCCO National Commission for the Certification of Crane Operators; ASME – American Society of Mechanical Engineers; IAPMO – International Association of Plumbing and Mechanical Officials**

Service Call 4: Burned Motor Windings
Service Call 5: Grounded Compressor

Reference
Electricity for Heating, Refrigeration and Air Conditioning

Category I: Heating

TASK 30. Install and Service Electric Heat

Theory of Electric Heat
The Electric Furnace
Electronic Furnace Wiring
- Interlocks
- Thermostats
- Multiple-Stage Electric Heating
- Electric Heating Safety Devices
- Fan Operation

Installation of Electric Furnaces
Electric Duct Heaters
Installing Duct Heaters
Troubleshooting Electric Heating Systems
- Airflow Problems
- Electrical Problems

Service Call 1: Defective Sequencer
Service Call 2: Defective Blower Motor
Service Call 3: Blocked Air Filter

Reference
United Association HVACR Training Manual
Electricity for Heating Refrigeration and Air Conditioning

TASK 31. Install and Service Gas Furnace

Combustion
- Combustion Efficiency
- Complete Combustion
- Incomplete Combustion

Testing Combustion
- The Draft Gage
- The Smoke Tester
- Carbon Dioxide Tester

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- Stack Thermometer

Fuels

- Natural Gas
- Manufactured Gas
- Liquefied Petroleum

The Gas Furnace

Furnace Components

- Heat Exchangers
- Fuel Delivery to the Furnace
- The Gas Manifold
- Primary and Secondary Air
- Fuel Ignition
- Venting and Removing Products of Combustion
- Fan Motor and Blower
- Fan Switches
- Limit Switches

Gas Furnace Installation

- Install the Gas Piping
- Install the Vent Piping on Conventional Furnaces
- Install the Vent Piping on Condensing Furnaces

Troubleshooting Gas Heating Problems

- Furnace Fails to Operate at All
- Inoperative Blower
- The Gas Valve
- Ignition Problems

Service Call 1: Shorted Gas Valve Coil

Service Call 2: Defective Fan Switch

Set Gas Pressure on an LP or Gas-Fired Furnace

Cut and Ream Steel Pipe

Manually Thread Steel Pipe

Install Steel Fittings on Threaded Steel Pipe

Reference

United Association HVACR Training Manual

TASK 32. Install and Service Oil Furnaces

The Oil Furnace

Fuel Oil

Combustion

Testing Combustion

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Combustion Chargers and Heat
Exchangers
Oil Delivery to the Unit

- Oil Storage Tanks
- Oil Lines
- Oil Filters
- Oil Deaerators

The Oil Burner

- Motor
- Fan
- Fuel Pump
- Nozzle Assembly
- Igniter/Transformer
- Primary Controls
- Nozzles
- Draft and Venting
- Power and Direct Venting
- Sizing and Installing the Flue Pipe

Troubleshooting the Oil Burner

- Air-Distribution System
- Fuel and Fuel Tank
- Oil Piping
- Oil Burner
- Combustion
- System Controls

Service Call 1: No Heat
Service Call 2: No Heat

Reference
United Association HVACR Training Manual

TASK 33-36. Install and Service Hydronic Heat

Theory of Hydronic Heating Systems

- The Heat Source
- Aquastat
- Reset
- Low-Water Cutoff
- Expansion Tank
- Centrifugal Pumps
- Air Vents and Air Separators

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- Press-Reducing Valve
- Pressure Relief Valve
- Zone Valves
- Flow-Control Valve
- Balancing Valve
- Series Loop System
- One-Pipe Systems
- Two-Pipe Direct Return
- Two-Pipe Reverse Return

Primary-Secondary Pumping

- Primary-Secondary Common Piping
- Primary-Secondary Circuit Piping
- The Circulator Pump
- Mixing Valves in Primary-Secondary Pumping
- Expansion Tanks in Primary-Secondary Systems

Radiant Heating Systems

- The Human Body is a Radiator
- Cold 70
- What is Ideal Comfort
- The Radiant System
- Radiant Heating Piping
- Tubing
- Manifold Station
- Water Temperature and Direct Piping

Installing and Starting the Hydronic System

- Install a Boiler
- Install the Piping
- Wire the System
- Fill the System
- Fire the System

Service Call 1: No Heat Upstairs
Service Call 2: No Heat Upstairs
Estimate the Volume of Water in the System
Calculate the Minimum Volume for the Expansion Tank
Fill and Purge the System

Reference

United Association HVACR Training Manual
Electricity for Heating, Refrigeration and Air Conditioning

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TASK 37. Install and Service Heat Pumps

Heat Pump Theory
- The Reversing Valve
- Check Valves
- Check Valves in Capillary Tube System
- Check Valves in Systems with Thermostatic Expansion Valves
- Suction Line Accumulators
- Bidirectional Filter Driers
- Bidirectional Thermostatic Expansion Valves

Heat Pump System Configuration
- Air-to-Air Heat Pumps
- Liquid-to-Air Heat Pumps

Defrost Methods
- Time-Initiated, Time-Terminated Defrost
- Time and Temperature Initiation, Temperature-Termination Defrost
- Solid-State Defrost

Geothermal Heat Pump Theory
- Geothermal Heat Pump System Configuration

Troubleshooting Geothermal Systems
- Water Circuit Problems
- Airflow Problems

Service Call 1: Defective Water Pump
Service Call 2: Mineral Deposits in the Water Circuit

Reference
United Association HVACR Training Manual
Electricity for Heating, Refrigeration and Air Conditioning

Category J: Soft Skills

TASK 38. Computer Skills

Basic Literacy
Program Thermostats
Upload and Download Files, Move, Copy, Search
Search Internet and Access Web
Adobe
Connect to Printer

Reference
United Association HVACR Training Manual

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TASK 39. Documentation (Invoicing)

Fax
Email
Complete Work Orders
Technically Describe Problems and Situations
Office Procedures
Invoicing – Accuracy, Estimate Time
Inventory Control – Accurate Records

Reference
United Association HVACR Training Manual

TASK 40. Customer Relations

Greet Customers
Vehicle Appearance
Communication Skills
Listening to Customer Skills
Personal Appearance
Handling Irate Customers
Handle Complaints
Explain Operating Instructions to Customers

Reference
United Association HVACR Training Manual

TASK 41. Ethics and Professionalism

Maintain Valid Driving License
Time Management (Scheduling Book)
Vehicle Appearance and Maintenance
Importance of Image (Vehicle and Personal)
Handling Money and Credit Cards
Background Checks
Parking Vehicle in Appropriate Places

- Courtesy and Proper Procedures for Operating Company and Commercial Vehicle

Reference
United Association HVACR Training Manual

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Category K: Light Commercial

TASK 42. Roof Top Package Units

Multiple Compressors
Two-Stage Gas and Cool
Economizer Cycles
Free Cooling
Low Ambient
Roofing and Water Proofing (Flashing and Curbs)
Condensate Drain
Roof Access and Location
Ladder and Rigging Safety
Remove Trash from Roof

Reference
United Association HVACR Training Manual
ARI Refrigeration and Air Conditioning 4th Edition
Modern Refrigeration and Air Conditioning
Electricity for Heating, Refrigeration and Air Conditioning
Air Conditioning, Mechanical Equipment Service Manual for UAJA

TASK 43. Ventilation Equipment

Direct and Indirect Fire
Make-Up Air
Building Pressurization
Outside Air
Smoke Evacuation

Reference
Air Conditioning, Mechanical Equipment Service Manual for UAJA

TASK 44. Exhaust Fans

Kitchen Hoods
Rooftop
Bathroom Exhaust Fans
Fire Suppression
Refrigerant Exhaust

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Reference

Air Conditioning, Mechanical Equipment Service Manual for UAJA
United Association HVACR Training Manual

TASK 45. Types of Air Volume Systems

Variable Air Volume Rooftops
Constant Volume
Zoning Systems

Reference

Air Conditioning, Mechanical Equipment Service Manual for UAJA

TASK 46. Rooftop Safety and Hazards

Exhaust Ducts on Roof
Ladders
Rigging
Openings and Skylights
Roof access
Remove Equipment and Materials Used on Roof
Gas Piping

Reference

Air Conditioning, Mechanical Equipment Service Manual for UAJA
Practical Heating Technology, Johnson, Delmar
www.osha.gov

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UA STAR Commercial Refrigeration

Category A: Refrigeration Fundamentals

TASK 1. Refrigeration Principles

Analyze system conditions, using a Pressure/Temperature (P/T) chart.
Identify refrigeration system components.
Explain the operation of a "simple" refrigeration system.
Calibrate a thermometer.
Read temperatures in a refrigeration system.
Define refrigeration cycle terminology.
Identify common abbreviations.
Explain heat transfer, in terms of sensible and latent heat, that occurs in the refrigeration cycle.
Define "refrigeration."
Identify the four major components of the vapor compression refrigeration cycle.
Explain the effects of: Superheating the suction gas, increasing the condensing pressure, subcooling the liquid.
Explain the importance of subcooling and superheat.
Separate the components of the high side from the low side of the refrigeration system.
Explain how fluids flow.
Identify the state, pressure, temperature, and condition of the refrigerant at key points in the refrigeration cycle.
Given a saturation temperature, determine the refrigerant pressure.
Given a pressure of a saturated refrigerant, determine its temperature.
Explain “temperature glide”.
Explain the function of major components of the refrigeration system.
Plot a P-H diagram for an operating refrigeration system.
Locate superheat specification on datasheet.
Explain how 25,400 microns compares to one inch of vacuum.
Explain system pressures and temperatures in terms of "saturation point", "sub-cooled liquid", and "superheated vapor".
Describe the relationship of air flow to pressures, temperatures and coil performance.
Describe the effect of non-condensable in the refrigeration system.
Identify requirements of product preservation.
Humidity requirements
Air quality (ambient)

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Reference
United Association HVACR Training Manual, Sections 1, 3, 21, and 25

TASK 2. Refrigerants and Oils

Explain problems occurring from using the wrong oil type.
Explain the pressure-temperature relationship of refrigerants.
Explain why systems using blended refrigerants must be charged as a liquid.
Identify type of refrigerant using pressure/temperature chart.
List common refrigerant types.
Match common refrigerant types with related color codes.
Match refrigerant types with the correct compressor oil type.
Recognize that refrigerant oil is heavier than refrigerant liquid.
Recognize that refrigerant oils are hygroscopic and take steps to avoid oil contamination.
Refrigerant Types:
- Hydrocarbon Refrigerants
- Hydrochlorofluorocarbon Refrigerants
- Chlorofluorocarbon Refrigerants
- Hydrofluorocarbon Refrigerants

Blended Refrigerants
Refrigerant Oils
- Alkylbenzene oils
- Glycols
- Esters

Safety Classifications and Nomenclature

Reference
United Association HVACR Training Manual, Sections 3 and 9

TASK 3. Refrigerant Safety

Demonstrate an understanding of safety policies and practices by passing the safety examination.
Demonstrate appropriate fire prevention and response.
Demonstrate use of safety tools, equipment and procedures.
Weight of a Refrigerant Drum (Tare Weight)
Disposable Vs. Reusable Tanks
Determine the safe capacity of refrigerant in a cylinder.
Identify conditions which cause refrigerants to become toxic.

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Reference
United Association HVACR Training Manual, Sections 4, 7 and 8

TASK 4. Refrigerant Handling and Transportation Regulations

Ozone, Ozone Depletion, and Global Warming
List at least five safety procedures to be followed when handling refrigerant cylinders.
410A
Refrigerant Recovery (Passive and Active Recovery)
Refrigerant Recycling
Refrigerant Reclaiming
Procedures

- Recovering Refrigerant from a System with an Operative Compressor
- Recovering Refrigerant from a System with a Self-Contained Recovery Unit

Reference
United Association HVACR Training Manual, Sections 3 and 9
United Association Environmental Protection Agency Training Manual, Page 38

Category B: Refrigeration System Operation

TASK 5. Piping

Fabricate and install hangers, struts, and supports.
Braze (Solder) Copper Pipe

- Solder Copper to Copper Pipe
- Solder Copper to Steel
- Solder Copper to Brass

Install pipe with proper pitch.
Insulate, glue, and cradle pipe.
Repair leaks on racks or single unit piping.
Explain purpose of suction line traps.
Explain when reduced risers are required.
Identify pipe fittings by sight.
Identify pipe size by sight (ID and OD).
Identify size of insulation used on medium- or low-temperature lines.
Explain proper procedures for underground piping.
Identify types of copper tubing.
Select the appropriate type of copper tubing for a given application.

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Identify types of brass fittings.
Select the appropriate type of brass fitting for a given application.
Identify types of hand and shut-off valves.
Select the appropriate hand valve or shut-off valve for a given application.
Demonstrate proper methods of component heat protection when brazing.
Demonstrate knowledge of proper nitrogen purge while brazing.
Explain the effect of nitrogen purging during brazing.
Explain proper pressure testing procedures and required micron level specifications.
Use charts and tables to calculate pressure loss from fittings and pipe runs.
Explain proper use of vibration eliminators.
Demonstrate knowledge of proper installation of vibration eliminators.
Demonstrate knowledge of proper sealing of threaded pipe connections.
Demonstrate knowledge of proper pipe flaring procedures.
Demonstrate knowledge of proper pipe swedging procedures.
Read refrigeration system legend.
Read store maps and diagrams.
Describe piping layout schemes.

Reference

United Association HVACR Training Manual, Sections 7 and 25
United Association Refrigeration Mechanical Equipment Service Manual, Pages 245-254

TASK 6. Compressor

Explain key factors relating to proper oil return to the compressor.
Explain the effect of reversed rotation on various compressor types.
Identify compressor components.
Identify compressor types.
Compare compressor suction pressure, discharge pressure, and power consumption to manufacturer's performance curves.
Demonstrate a fundamental understanding of a compound compressor.
Explain how to determine cause of compressor failure.
Determine size, BTUs and application.
Explain the purpose of capacity control systems.
Explain the relationship between discharge air temperature and liquid line differential settings.
Explain the three factors that control compressor capacity (suction pressure, compression ratio, and x).
Explain the typical cause of grounded compressor windings.

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Explain why it may be permissible to install a resistor across a single open thermistor in a compressor.
Identify devices used to protect against reverse rotation on some screw compressors.
List possible causes for broken compressor connecting rods.
Explain impact of high compression ratio.
Explain liquid injection system operation (demand cooling).
Explain oil level control valve operation.
Explain oil pressure safety switch operation.
Define the term "de-superheat" as it applies to compound compressors.
Identify typical applications of a satellite compressor.
Calculate compressor compression ratio.
Identify some factors that affect compressor capacity.

Reference

United Association HVACR Training Manual, Sections 3, 14, 23, 29, 36, 38 and 48

TASK 7. Condensers

Explain how to check for proper fan motor rotation and how to correct it, if necessary.
Explain how to determine the presence of non-condensable.
Identify condenser components.
Determine heat transfer of condenser.
Select appropriate condenser for application.
Identify condenser types:

- air cooled
- water cooled
- evaporative

Recognize failing condenser fan motors.
Explain proper fan cycling and sequencing.
Identify and explain the function of an air cooled condenser.
Describe the effect of non-condensable in the refrigeration system.
Replace motor on condenser.
Clean condenser.
Determine conditions that impact condenser capacity.
Explain split condenser operation.
Identify different methods of head pressure control and temperature.

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Reference

United Association HVACR Training Manual, Sections 3, 22 and 33
United Association Refrigerant Controls Manual, Pages 107-115

TASK 8. Expansion Devices

Identify TXV types:

- balance port
- conventional
- electronic
- pressure limiting
- automatic

Adjust superheat setting on TXV.
Explain the operation of various expansion valves.
Identify difference between internal and external equalizing.
Different Types of TX Valves for Different Refrigerants
Different Types of Temperature (C, Z, Limiting, Cross-Charges)
Identify different types of capillary tubes.
Identify different types of low and high side floats.
Distributors and T's

Reference

United Association Refrigerant Controls Manual, Pages 1-13, 15-21, 31- 35, and 43-51
United Association HVACR Training Manual, Section 24

TASK 9. Evaporators

How does air flow affects transfer heat variable.
Determine latent and sensible heat.
Different Refrigerant Configurations
Air flow (Counter Flow and Draw-Through) That Affects Air Flow Patterns
Use of Heat Exchangers
Condensate
Placement (Low Velocity vs. High Velocity)
Pressure Drop
Pitch of the Blade
Fan Blade Application
Explain pressure drop across a coil.

Reference

United Association Refrigerant Controls Manual, Pages 37-51, 428-430

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United Association HVACR Training Manual, Sections 3 and 21

TASK 10. Start-Up and Commission Systems

Refrigerant Leak Test (Check) with Electronic Leak Detector
Refrigerant Leak Test (Check) with Soap Bubble Solution
Refrigerant Leak Test (Check) with Nitrogen and Trace Gas (R-22)
Pressure Test a system with dry nitrogen.
Evacuate a system using three point evacuation.
Charge system with refrigerant.
Liquid Charge System
Vapor Charge System
Repair Leaks
Adjust EPR/SORIT valves.
Examine environmental conditions of the store.
Check refrigerant level and moisture.
Check oil level on all compressors.
Set condenser fan and pressure controls.
Adjust pressure regulating controls.
Adjust differential pressure regulating controls.
Check superheat and adjust expansion valve as required.
Set defrost schedule for cases and units.
Program and commission micro-controller.
Optimize energy management features.
Record initial system operating parameters (system vital signs).
Check electrical.
Explain operation to owner.

Reference

United Association HVACR Training Manual, Sections 4, 8, 10, 25, 28 and 38

Category C: Basic Electricity

TASK 11. Electrical Theory

Direct Current
Alternating Current
Ohms Law
Conductors
Insulators
Electrical Quantities

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Reference

United Association HVACR Training Manual, Sections 2 and 12
United Association Basic Electricity Manual, Pages 26-27, 33-35 and 83-87

TASK 12. Measuring Instruments

Voltmeters
Ammeters
Ohmmeters
Analog Meters
Digital Meters
Multimeters
Megometer
Microamp Meter

Reference

United Association HVACR Training Manual, Unit 5
United Association Basic Electricity Manual, Pages 43-55 and 67-128

TASK 13. Electrical Circuits (Series and Parallel)

Wiring Diagrams
Wire Size
Circuit Protection (Fuses, Circuit Breakers, GFCI)

Reference

United Association HVACR Training Manual, Sections 12, 15 and 17
United Association Basic Electricity Manual, Pages 43-60, 99-102 and 123-128
United Association Electrical Controls for Mechanical Equipment Service Manual, Page 7

TASK 14. Electric Service

120/240 V. Single-Phase Service
Three-Phase Service

Reference

United Association HVACR Training Manual, Sections 12, 17, 18, 19, and 39, Unit 5
United Association Basic Electricity Manual, Pages 83-87, 99-102 and 123-128

[1]NITC – National Inspection Testing Corporation; EPA – Environmental Protection Agency; OSHA –Occupational Safety and Health Administration; EPRI – Electric Power Research Institute; ESCO Institute; ASSE – American Society of Safety Engineers; NCCCO National Commission for the Certification of Crane Operators; ASME – American Society of Mechanical Engineers; IAPMO – International Association of Plumbing and Mechanical Officials

To ensure that all United Association (UA) apprentices and journeyworkers receive the appropriate skills and knowledge from any of the 330 UA authorized training centers (covering 284 registered apprenticeship programs and over 40,000 registered apprentices), the International Pipe Trades Joint Training Committee (IPTJTC) has committed tremendous resources to the development of curriculum, standards and certifications (including 3rd party groups[1]). The IPTJTC works in partnership with government, education, and industry groups (private and non-profit) in the development and validation of this material to assist in preparing these individuals for a successful career in the piping industry.

United Association Refrigeration Mechanical Equipment Service Manual, V1, Pages 276-277, 291-292 and 311-321
United Association Refrigeration Mechanical Equipment Service Manual, V2, Pages 515-516

Category D: Controls

TASK 15. Electric Motors and Starting Components

Motor Uses
Motor Power and Starting Torque
Motor Types
Single-Phase Motors
Three-Phase Motors
Variable Speed Motors
Procedures

- Identifying the Common, Start, and Run Terminals on a Split-Phase Motor
- Checking the Coil and Contacts
- Check Capacitors

Motor Starters and Contactors
Identify start circuit components.
Phase Monitors

Reference

United Association HVACR Training Manual, Sections 17, 18, 19, 25 and 39
United Association Electrical Controls for Mechanical Equipment Service Manual – Troubleshooting Guide, Page 29
United Association Refrigeration Mechanical Equipment Service Manual, V1, Pages 276-277

TASK 16. Automatic Controls and Devices

Overloads
Overload on Three-Phase Motors
Limit Switches
Fan Switches
Fan-Limit Switches
Thermostats (Line Voltage and Low Voltage Types and Programmable)
Magnetically Operated Devices (Solenoids, Control Transformers and Variable-Speed Motor Controls)
Electromagnetic Devices (Relays, Contactors, Motor Starters, Defrost Timers,

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Flow Switches, and Float Switches)
Pressure Switches and Controls (High, Low, Dual, and Oil Safety)
Electronic Controls (Solid-State Relays, Starting Relays, Timers, Thermistors, Transducers)

Reference
United Association HVACR Training Manual, Sections 14, 22, 24 and 25
United Association Refrigerant Controls Manual, Pages 1-13, 43-51 and 88-92
www.thermistor.com

TASK 17. Electrical Troubleshooting

Control-Circuit Problems:
- Holding Coils
- Thermostats
- Transformers
- Control Fuses
- Pressure Controls and Safety Devices
- Lock Out Circuits

Power-Circuit Problems:
- Contactors and relay contacts
- Circuit breakers and fuses
- Fan motors and compressor motors
- Capacitors
- Utility supply problems (under and over voltage problems)

Service Call 1: Blown Line Voltage Fuse
Service Call 2: Defective Transformer
Service Call 3: Defective Contactor
Service Call 4: Burned Motor Windings
Service Call 5: Grounded Compressor

Reference
United Association HVACR Training Manual, Section 25
United Association Refrigeration Mechanical Equipment Service Manual, Page 373

Category E: Rack Systems

TASK 18. Demonstrate General Knowledge of Rack Systems

Multiple Compressors with Parallel Racks (Common Piping)
Capacity Control

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Efficiency in Electrical Use
Pressure Control
Transducers
Load Distribution and Balance Load
Multiplex Systems

Reference
United Association HVACR Training Manual, Sections 19, 25 and 26

TASK 19. Install and Maintain Oil Control Systems

Importance of Oil Return
Install oil separator.
Cooling Oil with Refrigerant
Adjust oil regulators to generate proper oil level.
Adjust oil differential regulator to set pressure.
Install differential pressure check valve.
Recognize that refrigerant oils are "hygroscopic" and take steps to prevent contamination.

Reference
www.henrytech.com/Tips/HT-TT6.pdf
United Association HVACR Training Manual, Sections 25 and 26
United Association Refrigeration Mechanical Equipment Service Manual, Page 393

TASK 20. Add Liquid Sub-Cooling

Types—Mechanical and Ambient
Used to Cool the Oil and Reduce Temperature of Liquid Refrigerant

Reference
www.packless.com/subcool/subcool.html
United Association HVACR Training Manual, Sections 3 and 48

TASK 21. Perform Basic Service on "Rack" System

Install and remove refrigeration manifold gages.
Recover refrigerant from a system.
Perform evacuation and dehydration techniques.
Liquid and Vapor Charge a Refrigeration System
Determine system charge.
Determine and adjust superheat.

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Determine sub-cooling.
Use a sling/electronic psychomotor to check environmental conditions.
Explain the need to replace vacuum pump oil on a routine basis and after evacuation of a wet or contaminated system.
Identify when system evacuation is required.
Recognize a "wet" system.
Explain "Critical Charged System."
Locate and use technical references.
Weigh in refrigerant.
Adjust head pressure.
Check pressure drop across components.
Check electrical components.
Determine capabilities of the rack.

Reference
United Association HVACR Training Manual, Sections 3 and 29

Category F: Self-Contained Units

TASK 22. Metering Devices

Critical Charge for the Capillary Tube
Critical Charge for the Automatic Expansion Valve
Sizing of the Thermostatic Expansion Valve

Reference
United Association HVACR Training Manual, Sections 3, 24, 25 and 45

TASK 23. Charging Procedures

Vapor Charging
Liquid Charging
Check refrigerant charge.
Check superheat at compressor and sub-cooling.
Weigh in the charge for critically charged systems.
Control Applications
Determine temperature control per application.

Reference
United Association HVACR Training Manual, Sections 3, 9, 10, 24, 25 and 45

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TASK 24. Perform Maintenance on Self-Contained Unit

Check for abnormal noise or vibrations.
Check condenser air flow for restrictions.
Check refrigerant level.
Check for refrigerant, oil and water leaks (visual).
Check condensate pan/pump operation.
Clean condenser coil (wash or blow out).
Clean condensate pan.
Check and record system vital signs.

Reference
United Association HVACR Training Manual, Sections 14 and 25

Category G: Ice Machines

TASK 25. Clean and Sanitize the Machine

Remove ice from bin.
Use special cleaner to remove mineral deposits from evaporator and water-related components.
Change filters.
Flush system thoroughly.
Verify or adjust proper water level.
Purpose of Cleaning and Sanitizing – Eliminate Bacteria

Reference
United Association HVACR Training Manual, Section 27

TASK 26. Service Ice Machine

Start-up and check ice production.
Remove first two batches of ice.
Record initial system operating parameters (System Vital Signs):

- Ambient temperature
- Current draw
- Operating conditions

Check operating pressures.
Check water flow.
Take water temperature.
Calculate batch or cycle time for production or clock production.
Clean condenser on air- and water-cooled systems.

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Comply with manufacturer's recommendations.
Adjust float assembly, if necessary.
Check inlet water filter and check water quality.
Check water regulating valve on water-cooled systems.
Winterize ice machines:

- Drain and blow out all lines
- Disconnect power.

Reference
United Association HVACR Training Manual, Section 27
www.thermistor.com

Category H: Auxiliary Systems

TASK 27. Hot Water Heat Reclaim Systems

Operation and piping is critical.
Operation of Heat-Reclaim and Solenoid Valves
Water Flow
Recovery
Pressure Regulated Valve Operation and Problems with Loss of Head Pressure
Importance of Proper Charge with Change in Ambient Temperature, Except for Properly Designed Systems
Most Popular—Subcooling Liquid
Function:

- Improves System Efficiency
- Can be used to reduce flash gas for entering metering device.

Identify two types of subcooling use—ambient and mechanical.
Check for proper operation; replace unit, if required.

Reference
United Association HVACR Training Manual, Sections 22 and 26

TASK 28. Defrost Systems

Explain the need for defrosting.
Differentiate between defrost types and methods (hot gas, cool gas, electric, off-time, reverse air).
Explain store operations and affects on operation and settings of refrigeration system.
Explain the role of defrost in case operation.
List common defrost termination system types.

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Explain the terms "drip cycle" and "drain cycle."

Reference

United Association HVACR Training Manual, Sections 2 and 25
United Association Refrigeration Mechanical Equipment Service Manual, Pages 428-435

Category I: Business and Customer Relations

TASK 29. Establish Customer Relations

Acknowledge customer needs.
Resolve complaints.
Explain value of services to customer.
Clean work site.
Demonstrate customer telephone etiquette.
Explain service performed in layman's terms.
Perceive customer's preferred level of detail in explanations.
Communicate effectively with an angry customer.
Deal with technician delays and scheduling realities.
Explain contract terms.
Acknowledge customer needs.
Avoid escalation of emotion.
Communicate effectively.
Document product condition upon arrival.
Follow-up with customer.
Prioritize jobs.
Resolve complaints.
Sell yourself and the company to the customer.
Clarify customer's complaints.
Explain unit operation to the customer.
Describe unit problem to the customer.
Estimate repair costs.

Reference

United Association Customer Service Skills, Pages 13, 40, 47 and 49

TASK 31. Keep Records, Document Work Performed

Track/maintain inventory.
Document refrigerant handling/usage.

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Submit required paperwork
Complete startup/commissioning form
Prepare customer invoice/statement
Maintain vehicle records.
Maintain MSDS sheets.
Complete service report.
Complete warranty paperwork requirements.
Complete operating log.
Complete PM checklist.
Complete required business operations reports.
Use computer to order and track replacement parts, if available.
Warranty: Date parts to determine warranty coverage.

Reference
United Association Customer Service Skills, Page 47

TASK 32. Exhibit Professionalism

Participate in safety training.
Participate in technical training.
Obtain professional certifications.
Participate in continuing education and training.
Participate in OJL with co-workers.
Participate in professional organizations (e.g., RSES, ACCA, RETA).
Study manufacturer's service manuals and company safety manuals.
Read trade publications.
Maintain personal and vehicle appearance.
Keep tools and equipment in repair.
Avoid work related safety/health risks.
Demonstrate timeliness.
Recommend system improvements to management.
Respect the property of others.
Warranty: Follow warranty procedures regarding documentation, parts return.
Demonstrate flexibility in accepting work assignments that stretch his/her ability.
Demonstrate a willingness to learn.

Reference
United Association Customer Service Skills, Pages 35 and 38
United Association HVACR Training Manual, Unit 4

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